

DEVICE ENABLING DIFFERENT SPREADING FACTORS WHILST  
PRESERVING A COMMON SCRAMBLING CODE, IN PARTICULAR FOR  
TRANSMISSION IN A CODE DIVISION MULTIPLE ACCESS CELLULAR  
MOBILE RADIO SYSTEM

5           The present invention is generally concerned with  
spread spectrum communication systems, i.e. systems in  
which spectrum spreading is applied to a sequence of data  
to be transmitted, on transmission, using a spreading  
code, and, conversely, despreading is effected on  
10 reception, in order to find the original sequence.

BACKGROUND OF THE INVENTION

Spreading an incident data sequence of N symbols,  
denoted  $(d_1, d_2, \dots, d_N)$ , using a code of length (or  
spreading factor) Q, denoted  $c_q = (c_1, c_2, \dots, c_Q)$ ,  
15 produces a sequence of length Q.N, which can be  
represented as follows:

$$(d_1.c_1, d_1.c_2, \dots, d_1.c_Q, d_2.c_1, d_2.c_2, \dots, d_N.c_Q)$$

where  $d_1.c_1$  represents the multiplication of  $d_1$  by  
20  $c_1$ .

An alternative representation of the spread sequence  
of length Q.N is  $(d_1.c_q, d_2.c_q, \dots, d_N.c_q)$  where  $d_1.c_q$   
represents the product of the symbol  $d_1$  by the spreading  
code  $c_q$ .

A more general approach to spreading consists in  
25 having a different spreading code for each symbol of the  
input sequence, in which case the resulting spread  
sequence can be expressed in the form:

$$(d_1.c_q^{(1)}, d_2.c_q^{(2)}, \dots, d_N.c_q^{(N)}), c_q^{(1)} \text{ being the spreading code}$$

associated with the symbol  $d_1$ . All the spreading codes  
30 preferably have the same length Q so that the resulting

spread sequence has the length  $Q.N$ .

Figure 1 outlines the principle of spreading,  $T_s$  designating the basic period (or symbol period) of a non-spread sequence and  $T_c$  designating the basic period (or "chip" period) of a spread sequence,  $T_s$  and  $T_c$  being related by the equation  $T_s = Q.T_c$ . In the figure  $d_n$  and  $d_{n+1}$  correspond to two successive symbols of a non-spread incoming sequence and  $d'_1$  and  $d'_{1+1}$  correspond to two successive basic symbols (or "chips") of the same spread symbol of the incoming sequence.

One benefit of the above systems is enabling a plurality of users to share the same frequency band by allocating different users different codes.

One important application is Code Division Multiple Access (CDMA) cellular mobile radio systems.

In these systems, a spread sequence is generally scrambled prior to transmission using a scrambling code (or sequence), for various reasons including in particular improved protection against interference, or to assure the confidentiality of the information transmitted.

The scrambling of an incoming sequence of  $L$  basic symbols or "chips", denoted  $(d'_1, d'_2, \dots, d'_L)$ , by a scrambling sequence of length  $L$ , denoted  $(v_1, v_2, \dots, v_L)$ , produces a sequence of length  $L$  that can be represented as follows:

$$(d'_1.v_1, d'_2.v_2, \dots, d'_L.v_L)$$

The scrambling sequence can be a very long, typically pseudo-random sequence. A sequence of this kind protects against interfering signals by rendering them random, at least over the duration of said

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There is a need in these cellular mobile radio systems to be able to transmit data at a varying bit rate, in particular when the bit rate of the user itself varies (for example in the case of transmitting multimedia type data), or because, depending on the conditions for propagation of radio signals, a higher or lower degree of redundancy has to be introduced into the data to be transmitted in order to obtain a higher or lower degree of protection against transmission errors.

To increase the bit rate of data to be transmitted by a user for the same allocated frequency band (i.e. for the same duration  $T_c$ ), allocating the user a plurality of codes of length  $Q_m$  if the capacity of a single code of length  $Q_m$  is exceeded is known *per se*.

A technique of the above kind has the particular disadvantage of leading to some complexity of implementation.

Another technique known *per se*, which avoids the above disadvantage, is to reduce the length of the code allocated to the user so that the user continues to transmit on only one code in order to increase the bit rate of the data to be transmitted by that user for the same allocated frequency band (i.e. for the same duration  $T_c$ ). Figure 3 summarizes the principle of a technique of this kind, and uses the same type of representation as Figures 1 and 2, but for two different bit rates of the incoming sequence, respectively identified by suffices 1 and 2, in this instance for three successive symbols  $d_n$ ,  $d_{n+1}$  and  $d_{n+2}$  of the incoming sequence, the symbol period

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corresponding to  $T_{s1}$  for symbol  $d_n$  and  $T_{s2}$  for symbols  $d_{n+1}$  and  $d_{n+2}$ , and the code length corresponding to  $Q_1$  for symbol  $d_n$  and  $Q_2$  for symbols  $d_{n+1}$  and  $d_{n+2}$ .

A problem then arises due to the fact that a cellular mobile radio system may need to manage a plurality of users simultaneously whose instantaneous bit rates, and therefore whose spreading codes, are different and can separately take different values over time. The problem is that some algorithms, in particular decoding algorithms and especially the decoding algorithms referred to above, cannot, without modification, accept codes of different length for different users (whether at the same time or at different times). The cyclostationary nature of the sum of all the signals may have completely disappeared, for example, or it may have become too large to be useful.

#### OBJECTS AND SUMMARY OF THE INVENTION

A particular aim of the present invention is to provide a solution to this problem, in particular avoiding the need to modify these algorithms to enable them to accept combinations of codes of different lengths.

In one aspect the present invention therefore consists in a device enabling different spreading factors whilst preserving a common scrambling code, in particular for transmission in a code division multiple access cellular mobile radio system, the device including, on transmission, scrambling means for applying a scrambling code of length  $Q_{MAX}$  which is a multiple of said different spreading factors, to blocks of  $Q_{MAX}$  basic symbols obtained by spreading by means of any of said spreading

factors.

Accordingly each of the spread and scrambled sequences obtained in this way has a cyclostationarity of period proportional to  $Q_{MAX}$ , enabling efficient use of the interference rejection algorithms referred to hereinabove and consequently avoiding the disadvantages previously mentioned.

In another aspect the present invention also consists in a device enabling different spreading factors whilst preserving a common scrambling code, in particular for transmission in a code division multiple access cellular mobile radio system, the device including, on transmission, for spreading  $K$  incoming sequences by means of  $K$  respective spreading codes of respective length  $Q_k$  ( $k=1, \dots, K$ ) which is a sub-multiple of a maximum length  $Q_{MAX}$ , and scrambling the spread sequences obtained in this way:

- means for grouping the various data symbols of the  $k$ th incoming sequence ( $k=1, \dots, K$ ) into different blocks of  $Q_{MAX}/Q_k$  symbols,
- means for spreading the different blocks from the  $k$ th incoming sequence ( $k=1, \dots, K$ ) by means of the corresponding code of length  $Q_k$  to obtain a spread sequence including different spread blocks of length  $Q_{MAX}$ ,
- means for scrambling each of the  $K$  spread sequences obtained in this way using a scrambling code of length  $Q_{MAX}$ .

In another aspect the present invention also consists in a device enabling different spreading factors whilst preserving a common scrambling code, in particular for transmission in a code division multiple access

cellular mobile radio system, the device including, on reception, descrambling means for applying a scrambling code of length  $Q_{MAX}$  which is a multiple of said different spreading factors , to blocks of  $Q_{MAX}$  basic symbols  
 5 obtained by spreading by means of any of said spreading factors.

In another aspect the present invention also consists in a device enabling different spreading factors whilst preserving a common scrambling code, in particular  
 10 for transmission in a code division multiple access cellular mobile radio system, the device including, on reception, for descrambling and despreading an incoming sequence by means of  $K$  respective spreading codes of respective length  $Q_k$  ( $k=1, \dots, K$ ) which is a sub-multiple  
 15 of a maximum length  $Q_{MAX}$ :

- means for descrambling said incoming sequence using a scrambling code of length  $Q_{MAX}$ ,
- means for grouping the basic symbols of the spread and descrambled sequence obtained in this way in  
 20 different spread blocks of length  $Q_{MAX}$ ,
- means for despreading the spread blocks obtained in this way by means of  $K$  respective codes to obtain  $K$  despread sequences formed of different blocks of  $Q_{MAX}/Q_k$  symbols ( $k=1, \dots, K$ ).

25 The present invention also has for its object a mobile station (or mobile terminal), as well as an entity, in particular base transceiver station, for a mobile radiocommunication system, including a device of the above kind.

#### 30 BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and features of the present invention

will become apparent on reading the following description of one embodiment given with reference to the accompanying drawings, in which:

5 - Figure 1 is a diagram showing spectrum spreading of an incoming sequence,

- Figure 2 is a diagram showing spectrum spreading and scrambling of an incoming sequence,

- Figure 3 is a diagram showing spectrum spreading in the case of a variable length spreading code,

10 - Figure 4 is a block diagram of an example of a transmitter for a code division multiple access cellular mobile radio system to which the present invention can be applied,

15 - Figure 5 is a block diagram of an example of a receiver for a code division multiple access cellular mobile radio system to which the present invention can be applied,

20 - Figure 6 is a block diagram of an example of a device in accordance with the invention used on transmission,

- Figure 7 is a block diagram of an example of a device in accordance with the invention used on reception,

25 - Figure 8 is a diagram illustrating the operation of a device in accordance with the invention.

#### MORE DETAILED DESCRIPTION

The transmitter shown in Figure 4 includes:

- means 2 for spreading K incoming data sequences ST1 to STK using K respective spreading codes  $c_{Q_k}^{(1)}$  to  $c_{Q_k}^{(K)}$ ,
- 30 - means 3 for scrambling K data sequences ST'1 to ST'K from the means 2 using a scrambling code  $c_E$ ,



- modulator means 4 receiving the various sequences ST"1 to ST"K from the means 3,

- transmitter means 5 receiving the modulated signals from the means 4 and supplying the corresponding radio signals.

The receiver shown in Figure 5 includes:

- receiver means 6,  
- demodulator means 7,  
- means 8 for descrambling a data sequence SR" from the means 7 using said scrambling code  $c_E$ ,

- means 8 for despreading a data sequence SR' from the means 8 using K respective spreading codes  $c_{(1)}^{(1)}$  to  $c_{(K)}^{(K)}$ , and supplying K despread sequences SR1 to SRK to be used in processing means 10 by a decoding algorithm of the type mentioned above to supply a received data sequence SR.

The device in accordance with the invention, used on transmission, can be used in the spreading means 2 and the scrambling means 3 from Figure 4. In this case the device in accordance with the invention can be used in a base transceiver station for spreading incoming data sequences corresponding to different users served by the base transceiver station; it can also be used in a mobile terminal, by allocating different spreading codes to the user.

The device in accordance with the invention used on transmission shown in Figure 6 includes:

- means like the means 311 to 31K for grouping the data symbols of the kth incoming sequence ( $k=1, \dots, K$ ) into different blocks of  $Q_{MAX}/Q_K$  symbols  $(d_1^{(k)}, d_2^{(k)}, \dots, d_{Q_{MAX}/Q_K}^{(k)})$ .

- means like the means 321 to 32K for spreading the blocks obtained in this way from the kth incoming sequence ( $k=1, \dots, K$ ) using the corresponding code  $c_{Q_k}^{(k)}$  to obtain a spread sequence including spread blocks of

5 length  $Q_{\max} \left( d_1^{(k)} \cdot c_{Q_k}^{(k)}, d_2^{(k)} \cdot c_{Q_k}^{(k)}, \dots, d_{Q_{\max}/Q_k}^{(k)} \cdot c_{Q_k}^{(k)} \right)$ ,

- means like the means 331 to 33K for scrambling each of the K sequences ST'1 to ST'K obtained in this way using a scrambling code  $c_p$  of length  $Q_{\max}$ .

The means such as the means 311 to 31K are  
 10 controlled in accordance with the maximal length  $Q_{\max}$  and the corresponding code lengths  $Q_1$  to  $Q_K$ . If the length  $Q_k$  of at least one of these codes is variable, in particular in accordance with the bit rate of the corresponding incoming sequence, these means enable the number  $Q_{\max}/Q_k$  of  
 15 symbols per block to be varied, for the corresponding sequence, so that the product of this number by the length of this code remains constant and equal to  $Q_{\max}$ .

The device in accordance with the invention is used in particular in the descrambling means 8 and the  
 20 despreading means 9 from Figure 5. In this case of application to despreading, the device in accordance with the invention can be used in a base transceiver station or in a mobile terminal to despread an incoming data sequence, not only by means of the spreading code  
 25 allocated to a given user (or by means of one of the codes allocated to that user if they are allocated more than code), but also by means of the codes allocated to other users (and possibly other codes allocated to the user in question), in order to use a decoding algorithm  
 30 such as those mentioned hereinabove.

The despreading device shown in Figure 7 includes:

- means 34 for descrambling the incoming sequence SR' using a scrambling code  $c_2$  of length  $Q_{MAX}$ ,

- means 35 for grouping the data symbols of the descrambled sequence SR' obtained in this way into different spread blocks of length  $Q_{MAX}$ ,

- means such as the means 361 to 36K for despreading the spread blocks obtained in this way by means of respective codes such as the codes  $c_{Q_1}^{(1)}$  to  $c_{Q_K}^{(K)}$  to obtain K despread sequences SR1 to SRK formed of different blocks of  $Q_{MAX}/Q_k$  symbols ( $k=1, \dots, K$ ).

As indicated above, this avoids the need to modify the decoding algorithm to have it accept combinations of codes of different length.

Implementing the various means constituting the block diagrams of Figures 6 and 7 will not represent any particular problem to the skilled person, so such means need not be described here in more detail than by reference to their function.

Note that these diagrams are theoretical diagrams but clearly in practice the structure can be different, in particular the various component parts of the diagrams can be grouped together in common signal processor means.

The operation of a spreading or despreading device in accordance with the invention is shown in Figure 8, where S corresponds to a non-spread and non-scrambled sequence, S' corresponds to a spread and non-scrambled sequence, and S'' corresponds to a spread and scrambled sequence.

The figure shows, by way of example:

- two successive blocks  $B_i$  and  $B_{i+1}$  of length

$Q_{MAX}/Q_k$  of data symbols from the sequence S,

- two successive spread blocks  $B'i$  and  $B'i+1$  of length  $Q_{MAX}$  of the spread sequence  $S'$ ,

5 - two successive spread blocks  $B''i$  and  $B''i+1$  of length  $Q_{MAX}$  of the spread and scrambled sequence  $S''$ .

Note also that what has been described can be varied in diverse ways; in particular, for improved efficiency, the spreading code can be different for the various symbols of a data sequence to which it applies.

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